theory, if we intend to grapple with every kind of proposition we require a threefold division. We must be able to show that a compartment is empty, that it is occupied, or that we do not know what is its state.

Speaking only of diagrammatic illustration, since it is to this that Mr. Sidgwick is referring, I may say that I have indicated in an article in *Mind* (1883, p. 599) how such a threefold scheme of alternatives could be displayed. Reference to this will be found also in Mr. Keynes's "Formal Logic."

I cannot ask for space to discuss the subject fully here. But I would remark that any scheme that confines itself to *two* alternatives seems to me to be necessarily open to one or other of two serious drawbacks. Either (1) we have to assume that the assertion of a proposition carries with it the existence of its subject. This begins plausibly enough; but when fully worked out it forces us to abandon various universally recognized rules, such as some of those for conversion, contraposition, &c. It also, in the case of complex propositions, departs even further from convention than the opposite doctrine does. And it wholly fails to express hypothetical propositions. I have pointed out these difficulties in my "Symbolic Logic," and the first of them will be found very fully treated by Mr. Keynes. Or (2) we may reject the assumption just mentioned, as Boole and Jevons practically do. We are then wholly unable (in spite of the attempts made by each of these writers) to express *particular* propositions.

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THE PARIS ASTRONOMICAL CONGRESS.

IN our last article we brought down our reference to the *procès-verbaux* as follows:—General Congress meeting, April 19; Photographic Committee meetings, April 20 and 21; Astronomical Committee meetings on the 20th, 21st, and 22nd. We have since then received from Admiral Mouchez the following records:—Third and fourth meetings of the Congress on the 23rd and 25th; meeting of the Permanent Committee on the 26th; and meeting of the Permanent Bureau on the 27th. The two final meetings of the Congress were held chiefly to receive the reports of the Astronomical and Photographic Sub-Committees which have been appointed, and to whose proceedings we have referred in detail, and also to appoint a Permanent Committee, and if necessary a Bureau.

It will be convenient, then, that we should commence by referring to the third and fourth general meetings held on the 23rd and 25th. This first meeting considered the various resolutions which had been arrived at by the Sub-Committees, and the discussions upon them do not appear to call for any more remarks upon our part. With regard to the construction of the object-glass for the light near G, the eminent optician, Steinheil, communicated a note which will appear among the records of the Congress, but of which no details are given in the *procès-verbal*. With regard to the supplementary negatives which are to be obtained for purposes of a catalogue of the stars of reference, the Astronomer-Royal was evidently under the impression that to endeavour to obtain stars of the eleventh magnitude might be going a little too far, and he therefore proposed that a resolution should give authority to the Permanent Commmittee to determine down to what magnitude, not beyond the eleventh, these photographs should include. The Astronomer-Royal also was evidently under the impression that the Congress had been called together to obtain a photographic autobiography or map of the heavens in this present century chiefly, and that it should not lay so much stress as the astronomers present were inclined to do upon a mere catalogue.

Mr. Gill, Her Majesty's Astronomer at the Cape, seems to be of a different opinion, as he remarked that it is necessary to make a catalogue if the thing is possible. The number of stars to appear in the catalogue if the eleventh magnitude is adopted will be about 1,500,000 according to M. Paul Henry, and according to Dr. Schoenfeld, if the 11·5 magnitude were adopted no less than 3,500,000 stars. Subsequently the matter was put to the vote, and the resolution as it came down from the Astronomical Section was approved, Mr. Christie's amendment being lost.

The Congress next passed on to consider the distribution of work among the different Observatories. MM. Beuf and Cruls, representing the Observatories of La Plata and Brazil, were the first to reply that they were ready, it being understood that the price of a telescope similar to that employed by the Brothers Henry would be something like 40,000 francs. Admiral Mouchez stated that it had been decided that the Observatories of Algiers, Bordeaux, Paris, and Toulouse would represent the part which the French Government would be prepared to take, and he also stated that in all probability the Observatory of Santiago in Chili could undertake some portion of the work. M. Weiss stated that the participation of the Vienna Observatory might be regarded as certain. MM. Tacchini and Oom, representing the Observatories of Rome and Lisbon, had little doubt that their Governments would furnish the requisite sums. M. Dunér stated that the Senate of the University of Helsingfors would contribute a photographic refractor, and he did not anticipate any difficulty with his Government. M. Struve had no instructions; M. Auwers was in the same case; Messrs. Christie and Gill followed suit. Mr. Russell declared that in his opinion the necessary funds would be provided to enable the co-operation of the Observatories of Melbourne and Sydney to be assured. Mr. Peters said that he had no doubt that there would be ten Observatories in America anxious to help in the work, but he did not know if they would accept all the terms and conditions of the resolutions of the Congress. M. Pujazon, representing Cadiz, thought that he could promise assistance towards the map, but he could promise nothing relating to the catalogue.

M. Foli, representing Brussels, then proposed the following resolution:—

"If an astronomer takes, by means of a telescope different to that suggested by the Committee, photographs which fulfil the conditions laid down for the map, he shall be able, with the concurrence of the Permanent Committee, to join in the execution of it."

This was subsequently withdrawn.

The final meeting of the Congress was held on the 25th, and the point first discussed was that relating to the Permanent Committee. M. Knobel proposed, on behalf of some of the French astronomers, the following resolution:—

"That there should be two categories of members in the Permanent Committee—first, the Directors of Observatories where the work is carried on; and secondly, others not necessarily taking part in the construction of the map. This Permanent Committee should name its own Bureau, consisting of a President, two Vice-Presidents, and two Secretaries."

Next followed a discussion as to the number of members of which the Committee should consist. A considerable difference of opinion was made manifest by the remarks of many members of the Committee, and Admiral Mouchez, with the apparent intention of coming to an agreement, proposed the following series of resolutions:—

(1) "Before separating, the International Congress shall delegate its powers to a Commission of eleven members, forming an Executive Commission, charged to study all the questions which have been referred to, and to hasten the preparations for the execution of the map as much as possible. The Directors of Observatories

who shall obtain from their Governments instruments constructed according to the decisions adopted by the Congress shall take part in the work and be members of the Commission."

(2) "The Executive Commission shall meet once a year in one of the cities named beforehand where one of the Observatories is situated. Those members who cannot take part in this reunion shall forward their remarks upon the principal questions to be discussed, of which the President of the Commission shall give notice one or two months beforehand."

(3) "Between these annual meetings, the President should keep himself in communication with the members, and receive or give advice on all matters touching the preparation or execution of the work and the progress already effected."

(4) "The division of the heavens between the different Observatories, and all questions not settled by the Congress, must be fully studied in advance, so that they may be decided in a definite way, at least in two years' time, at a meeting in 1889, by which period many instruments will be ready to begin work."

On the occasion of the Universal Exhibition, Paris will probably be the city most convenient for this second meeting.

(5) "While the map is in progress, each Director who takes part in the work shall send to the Permanent Committee one or two months before each meeting, stating the work done, together with any remarks which he may consider necessary."

(6) "The *procès-verbaux* of these annual meetings, and the resolution of all work done, shall be published regularly, and sent to each Observatory."

The President, M. Struve, asked if M. Knobel would withdraw his resolution in favour of that of Admiral Mouchez. Finally, after some discussion, part of M. Knobel's resolution was carried, all except that portion relating to the constitution of the Bureau.

It was next determined that the number of members of the Permanent Committee, beyond those Directors of Observatories who have declared their readiness to join at once, should be eleven. The members elected were Christie, Dunér, Gill, Paul Henry, Janssen, Lœwy, Pickering, Struve, Tacchini, Vogel, Weiss.

The following resolution was next carried, proposed by M. Auwers:—

"The Congress resolves that it is desirable to appoint a Sub-Committee occupying itself with the application of photography to astronomy, other than the construction of the map, showing the importance of all these applications and the relations which it is important to establish between these different kinds of work. This Committee should place itself in relation with the Permanent Committee. The Congress desires that MM. Common and Janssen be charged to carry out this resolution."

The thanks of the Congress to the French Government, Admiral Mouchez, and the President, M. Struve, brought the Congress to a close.

The first meeting of the Permanent Committee was held on April 26, M. Struve in the chair; M. Trépied was requested to act as Secretary. Much time was spent in discussing whether a Bureau or Sub-Committee should be appointed, although the relation of this Bureau or Sub-Committee to the Permanent Bureau appointed at the last meeting of the Congress does not come out very clearly. Admiral Mouchez stated that the Bureau to be elected at the present meeting was rather an Executive Committee than a deliberative one. This was generally agreed to. The composition of the Bureau was then fixed at one President, five Members, and three Secretaries, and the members elected were as follow:—President: Admiral Mouchez; Members: Messrs. Struve, Christie, Tacchini, Dunér, and Janssen; Secretaries: Gill, Vogel, and Lœwy. M. Vogel then suggested that his colleagues on the Permanent Committee should present to the Bureau before July 1 next any propositions they might have, concerning experiments to be undertaken, and other preparatory work. He suggested also that the Bureau should be allowed to confide directly to men of science, possessing special knowledge, some of the researches which the International Congress has left to the Permanent Committee the responsibity of undertaking and directing.

After discussion of all the documents thus received, a definite plan of preparatory work might be elaborated and distributed among the different Observatories. Admiral Mouchez then stated that the Academy of Sciences would bear all the expenses of printing connected with the work, and it was also agreed that all documents should be sent in French. The Astronomer-Royal was requested to undertake experiments with curved plates. M. Struve promised in a month's time to forward suggestions relating to the methods of proceeding to be adopted by the Bureau. It was further decided that all memoirs and communications should be addressed to the President, and distributed by him and the Secretaries residing in Paris.

The last question discussed was the probable number of Observatories. Mr. Gill remarked that the small number of Observatories in the southern hemisphere were almost all situated in the same latitude, and he suggested that if France would establish a new Observatory in the Island of Réunion or New Caledonia, probably the Government of New Zealand might establish another in that colony. The general opinion was that the Island of Réunion would be better than New Caledonia as a station, and that the Observatory in New Zealand should be built in latitude about 48° S. The following resolution was unanimously adopted:—

"The Permanent Committee of the International Astronomical Conference met together for the construction of a photographic chart of the heavens, and finding that the number of Observatories in the southern hemisphere was insufficient for the good and prompt execution of the work, expressed a desire that two new Observatories might be erected, at least as a temporary measure, one in New Zealand, the other in the Island of Réunion."

The President was charged with the duty of transmitting this resolution to the English and French Governments.

Finally, we come to the Bureau of the Permanent Committee, which held its first sitting on April 27, M. Struve being President.

Mr. Gill announced that Sir James Anderson, Director of the Eastern Telegraph Company, has provisionally authorized the exchange of free telegrams between the Cape and Paris. Thanks were unanimously voted to Sir James Anderson for this offer. All members of the Committee were requested to reply within a month to any question addressed to them, and six was made a quorum. Mr. Gill volunteered to draw up complete instructions regarding all photographic operations. The assistants appointed to conduct the photographic work in the Observatories now taking up photography for the first time are to be trained in Observatories where photographic work is already carried on.

The institution of a series of test objects was then agreed to, and Messrs. Gill, Vogel, and Henry, were requested to draw up a list. On the proposal of Admiral Mouchez, the following distribution of the experimental work was agreed to:—

(1) Systems of cross-wires.—M. Vogel.

(2) Photographic magnitudes.—Messrs. Struve and Pickering.

(3) Optical determinations of images by means of photographs supplied by the Brothers Henry.—M. Struve.

(4) The study of three or four stars nearly in a straight line embracing the total angular distance of about 1°, and photographed necessarily at the centre and at the corner of a plate.—Paris, Algiers, Pulkowa, and Leyden.

(5) Study of the deformations of films.—Algiers, Meudon, and Potsdam.

(6) Study of curved plates from the triple point of view of construction, means of covering with a film, and measures.—Mr. Christie.

(7) Study of absolute orientation—that is to say, the mounting of the plates in the photographic telescope.—The Cape and Paris.

(8) Study of the measuring-instruments to be applied for the future utilization of negatives.—This was postponed.

(9) The study of formulæ for the preparation of plates in accordance with the general rules laid down by the Conference—Messrs. Abney and Eder.

(10) Opinions of colours of stars on their photographic magnitudes.—M. Dunér.

THE TEMPERATURE OF THE CLYDE SEA-AREA.[1]

II.

FROM the curves for each station, temperature sections were constructed for every cruise, showing the position of the isotherms with relation to a profile of the bottom along certain lines. It is not easy to give an intelligible description of the distribution of temperature without reference to those diagrams; but an attempt may be made. The most important section runs from the Channel, across the Plateau, up the Kilbrennan Sound branch of the Arran Basin, through Inchmarnoch Water, to the head of Loch Fyne. It is sufficient to recollect that the Plateau is covered by about 25 fathoms of water, that the depth increases on the inside up to 107 fathoms off Skate Island, then diminishes rapidly to 15 fathoms at Otter and Minard, and increases again to nearly 80 in Upper Loch Fyne. The section is a little more than 90 miles long.

In April the whole section was filled with water between 41°·3 and 44°. The water of the Channel, the Plateau, and the surface layers (to 10 or 20 fathoms) was above 42°. The average bottom temperature was 41°·3, except in the Channel (42°), and in Upper Loch Fyne (41°·9). The June section shows marked surface heating to a depth of about 5 fathoms. Water at 47°·5 filled the Channel, covered the Plateau, and extended in a layer of about 5 fathoms thick over the inner reaches. The great mass of water was between 44°·5 and 44°. In Upper Loch Fyne the remarkable distribution of temperature, referred to when discussing the curves for Strachur, was found to extend from Minard to the head of the Loch, in the form of a lenticular mass of water of temperature under 44°, with warmer water above and below. The minimum temperature, 42°, was found off Inveraray at a depth of 30 fathoms, and the gradient of temperature was much steeper in the upper layers of the cold mass than in the lower. No satisfactory explanation of the mode of formation of this intermediate minimum of temperature has yet been arrived at, and any suggestions as to its origin would be received with interest. In August the section shows that the cold mass remained in the same position but with a rather higher temperature, and of much smaller dimensions. As in previous months, the warmest water was that nearest the Atlantic, which had a temperature of over 53°. The great Arran Basin presented a considerable range; from 54° on the surface to 50° at 20 fathoms, 48° at 30, 46° at 60, and 45°·3 on the bottom. The September cruise showed a very similar state of matters, accompanied by a general rise of temperature and an increase in thickness of the warmer layers. As in each previous month, the Channel was warmest (54°·5 throughout), and the warm surface layer became thinner and thinner until at Otter the surface temperature was under 53°. The section clearly shows, what careful experiments have proved, that the abrupt rise of the sea-bottom, from off Skate Island at 107 fathoms to Otter at 15, is characterised by a rise of colder water from beneath to the surface. The gradient at this place is 550 feet in ten sea-miles, or 1 in 100; and perhaps vertical circulation is set up as much by the sudden narrowing of the Channel, as by its shoaling. A similar effect was observed at Row Point in the Gareloch, and at the narrowest part of the Kyles of Bute. In September the bottom temperature of the Arran Basin was 47°·5, that of Upper Loch Fyne 44°·2; the intermediate minimum had disappeared from the latter. November showed the influence of surface cooling in a marked degree. The Channel and Plateau had cooled down to 50°, and for the Arran Basin the average surface temperature was 49°·5, that at the bottom 51°·5. This shows a great equalisation of temperature, and a reversal of the summer conditions, the warmer water being now below, the cooler on the surface. In Upper Loch Fyne the temperature was 44° at surface and bottom, but a maximum of a little over 50° was found at 15 fathoms. Further cooling and greater equalisation of temperature characterised December; the Channel was warmest, at 48°·5; the whole Arran Basin varied from 46°·8 on the surface to 47°·5 on the bottom; and Loch Fyne maintained its independent position by a quite new arrangement of temperature-layers. On the days of our work there (December 29 to 31) the whole upper part of the Loch was covered with a sheet of frozen fresh water, the ice being nearly half an inch thick in places. Three inches beneath the ice the temperature was 36°, and a few feet under, it was 44°. The maximum temperature of 47°·5 was met at 20 fathoms; and the warm layer of water was giving out its heat to the superficial strata, being cooled by this winter's cold, and to the lower mass which still retained the cold of last winter, although the bottom temperature had risen about half a degree since November. In February it was impossible to observe in the Channel on account of bad weather, but the water on the Plateau was slightly colder (43°·4) than that in the Arran Basin (43°·7 to 44°). There was little range of temperature, the surface being in all cases, however, slightly colder. Throughout the Arran Basin the temperature of the mass of water was the same as in June: this may be held as pointing to the end of April as the period of minimum. Loch Fyne showed a steady rise of temperature as the depth increased down to 45 fathoms, where the thermometer registered 46°·5; from that point to the bottom there was a fall to 45°·8.

Dividing the Clyde sea-area into three parts, each comprising regions of like physical configuration, the direction of the annual march of temperature may be summed up thus.

Starting from the simple case of a minimum uniform distribution, the Channel heats uniformly up to September. and then cools uniformly; the strong tidal currents, or some other cause, keeping the water thoroughly mixed, and equalising all heat transactions.

The deep open basins, to which the tide has free access, heat up most rapidly on the surface, and more uniformly lower down; the mass which heats uniformly decreases until at the period of maximum there is an unbroken fall of temperature from surface to bottom, and a considerable range. Then, at the autumnal equinox, the surface water begins to cool, while summer heat is still travelling downwards: this leads to the typical winter state—exactly complementary to the summer condition—of a uniform gradient of temperature rising from surface to bottom, but with a slight range. As winter goes

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[1] Continued from p. 39.